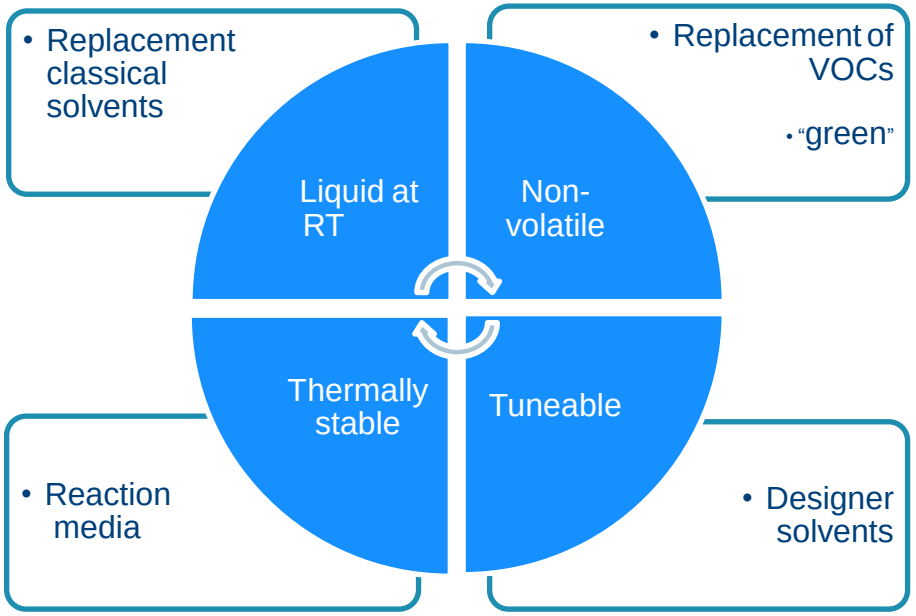
Temperature-dependent miscibility of non-fluorinated ionic liquids in water

Daphne Depuydt

Ionic Liquids

Solvents that consist entirely of ions



Synthesis

- functional design of novel ILs

Thermomorphic behavior

- Investigation of temperature-dependent miscibility in water

HLLE

- Extraction of metal ions

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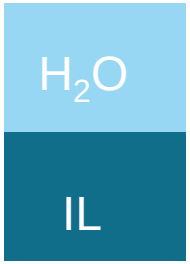
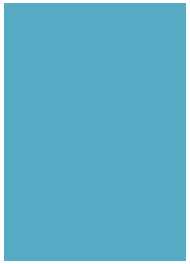
Miscibility with water



Hydrophobic ILs

Hydrophilic ILs



PF_6^-

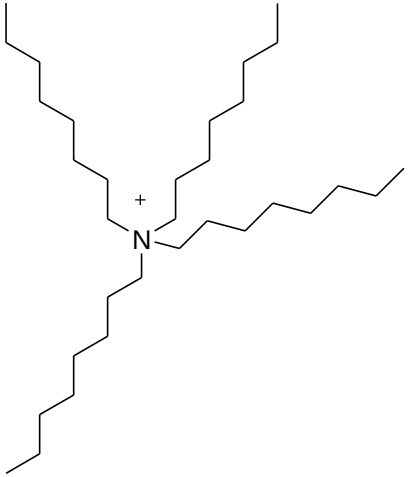
Tf_2N^-

Changing the nature of the ions

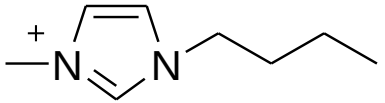
anion

Cl^- Br^-

CH_3COO^-



cation



Miscibility with water

H_2O

IL

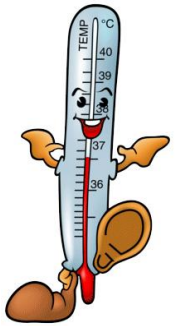
Addition of salts

Aqueous Biphasic Systems

Miscibility with water

H_2O

IL



Changing the temperature

Thermomorphic Ionic Liquids

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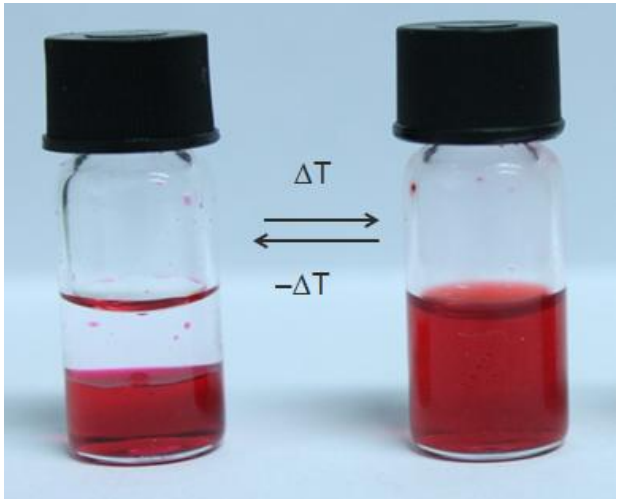
Thermomorphic Behavior

= temperature-dependent miscibility of IL in water

- Dynamic and reversible phase change between homogeneous phase and liquid/liquid biphase



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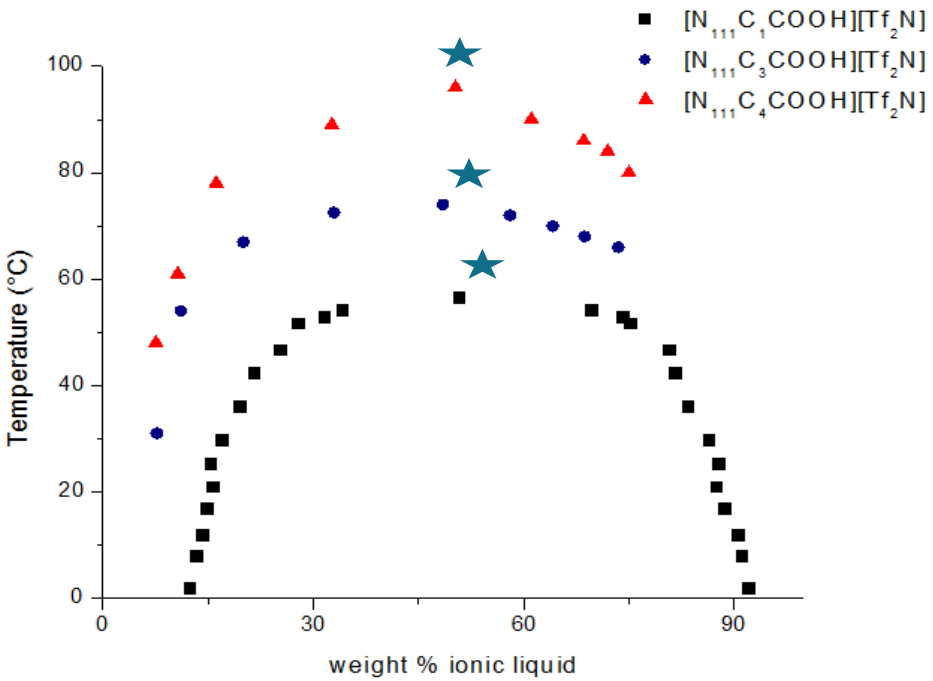
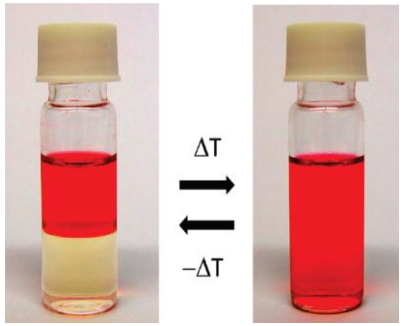
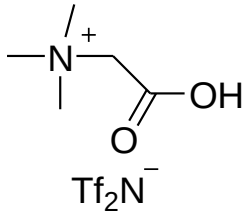
Temperature-Dependent Miscibility

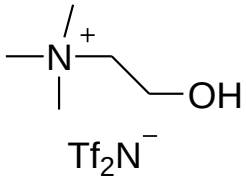
UCST







55 °C

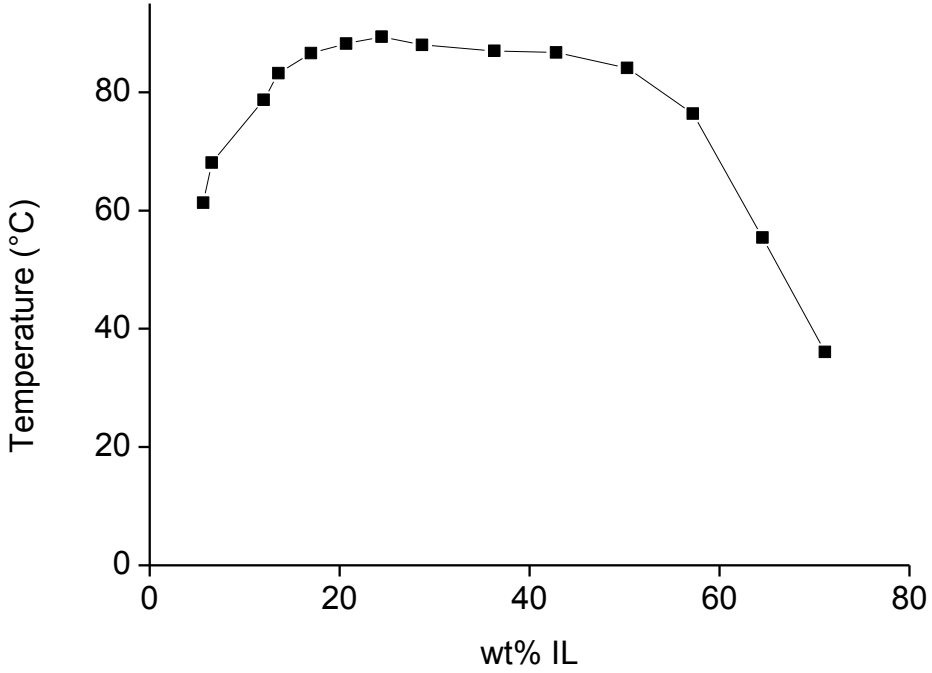


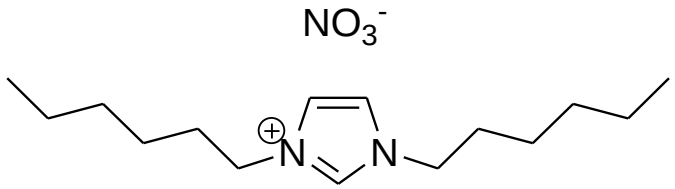
72 °C

Nockemann, P.; *et al.* Task-Specific Ionic Liquid for Solubilizing Metal Oxides. *J. Phys. Chem. B* **2006,** *110,* 20978.
Nockemann, P.; *et al.* Temperature-Driven Mixing-Demixing Behavior of Binary Mixtures of the Ionic Liquid Choline Bis(Trifluoromethylsulfonyl)Imide and Water. *J. Phys. Chem. B* **2009,** *113,* 1429.

Temperature-Dependent Miscibility

UCST

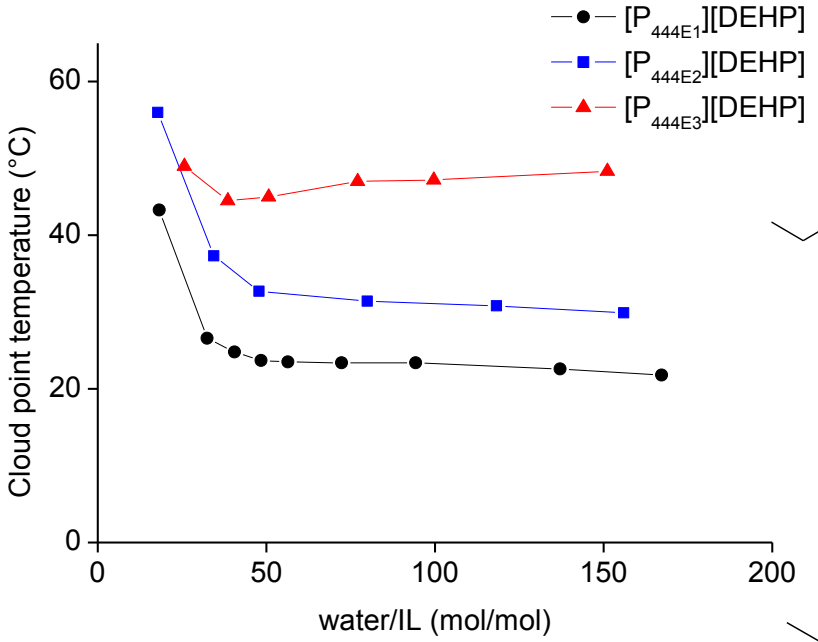


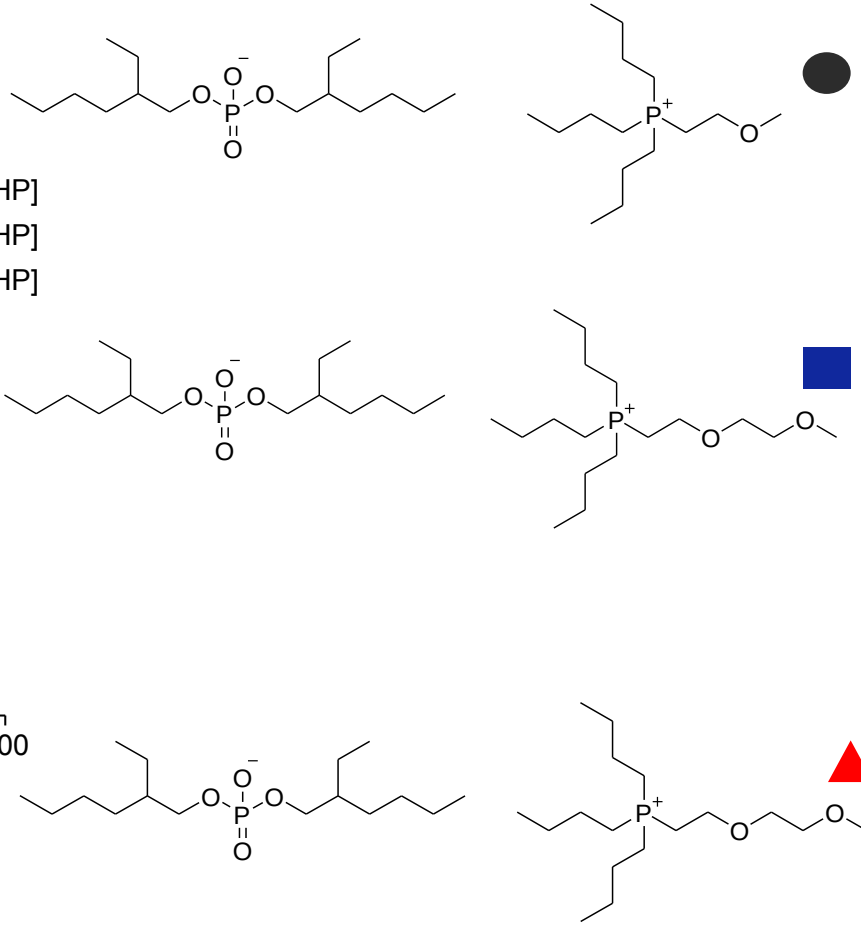


Opportunity to extract rare earths

Temperature-Dependent Miscibility

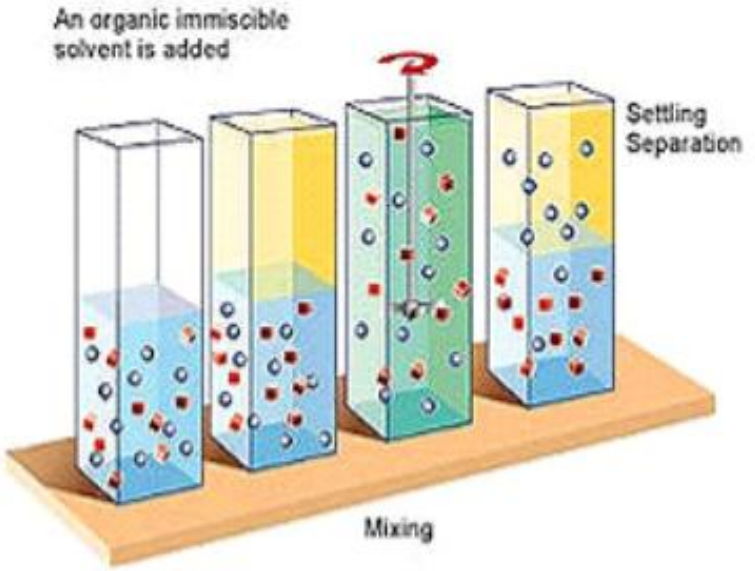
LCST

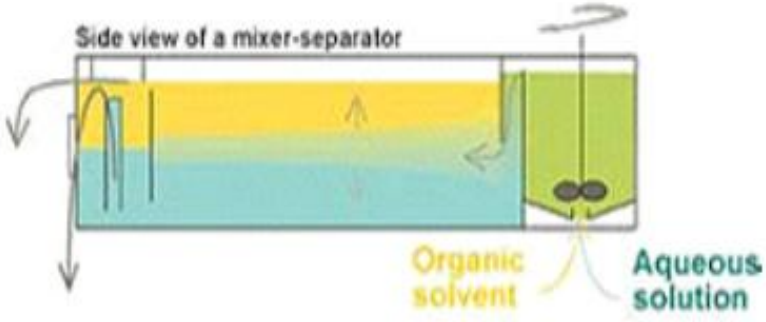




Applications

- Electrochemistry
- Engineering
- Analytics
- Solvents
  - Separation of metal ions

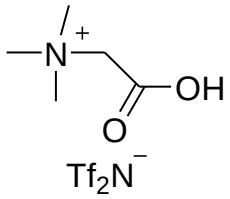




Conventional Solvent Extraction

Extraction of metal ions

HOMOGENEOUS LIQUID-LIQUID EXTRACTION

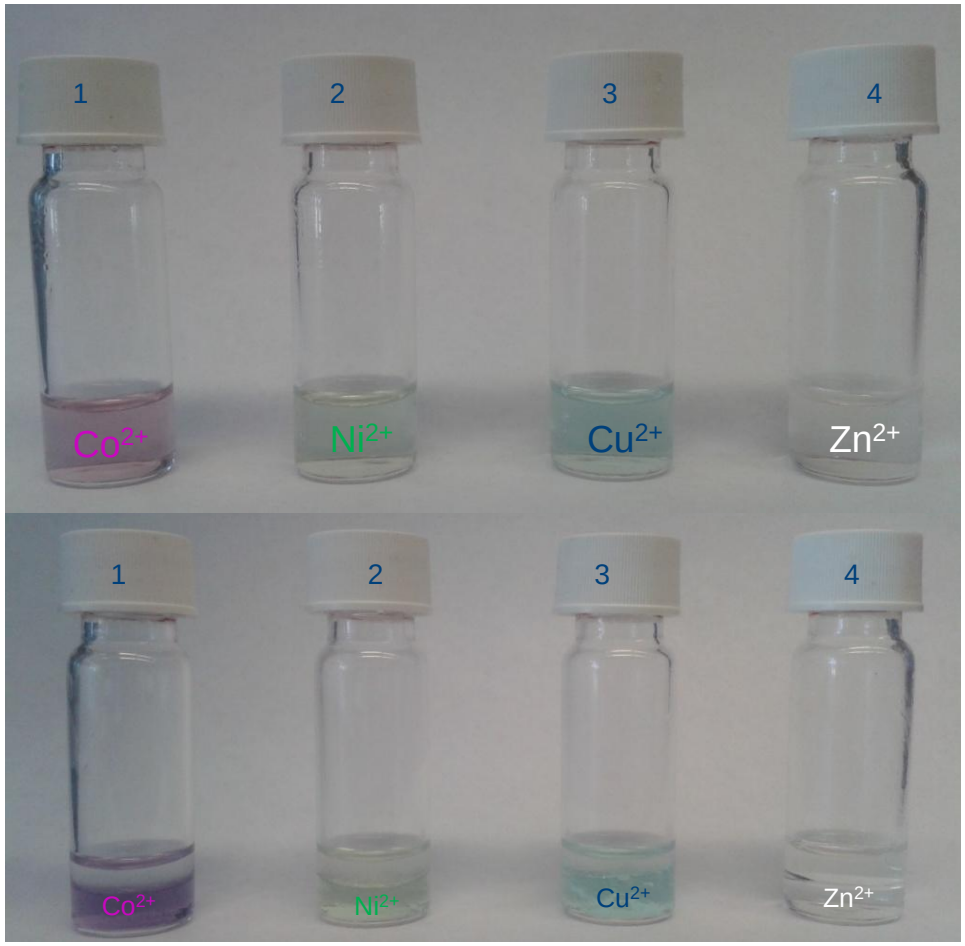


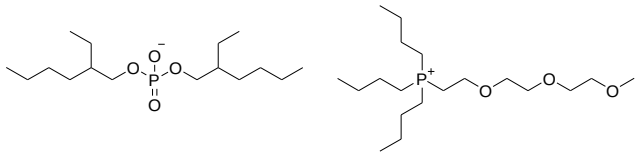
UCST

Vander Hoogerstraete, T.; Onghena, B.; Binnemans, K. Homogeneous Liquid-Liquid Extraction of Metal Ions With a Functionalized Ionic Liquid. *J. Phys. Chem. Lett.* **2013,** *4,* 1659.

Extraction of metal ions

HOMOGENEOUS LIQUID-LIQUID EXTRACTION





Homogeneous region
5 °C

LCST

Biphasic system
25 °C

H_2O

IL

Extraction of metal ions

HOMOGENEOUS LIQUID-LIQUID EXTRACTION

Metal ion	C_i (ppm)	C_{aq} (ppm)	*D*	*%E*	*%S*
Co^{2+}	6866	1278	4	81	99
Ni^{2+}	5578	286	19	95	99
Cu^{2+}	4480	128	34	97	58
Zn^{2+}	7466	285	25	96	91

H_2SO_4

%S = 99%

Extraction: $D = \frac{c_{\text{in}} - c_{\text{aq}}}{c_{\text{aq}}}$

$\%E = \frac{c_{IL} m_{IL}}{c_{IL} m_{IL} + c_{aq} m_{aq}} \times 100\ \%$

Stripping: $\%S = \frac{c_{\text{ILbs}} - c_{\text{ILas}}}{c_{\text{ILbs}}} \times 100\ \%$

Precipitation stripping with oxalic acid

Irving-Williams series:
Co < Ni < Cu >Zn

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- Prof. K. Binnemans
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Thank you for your attention

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